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APPLICATION NUMBER: *60/457,280*
FILING DATE: *March 25, 2003*

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03-26-03 60457280 .032503

jc600 U.S. PTO 03/25/03

60/457280 U.S. PTO

PTO/SB/16 (10-01)
Approved for use through10/31/2002. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Express Mail Label No. EU599925776US

INVENTOR(S)

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☑ *Additional inventors are being named on the* 2 *separately numbered sheets attached hereto*

TITLE OF THE INVENTION (500 characters max)

PROCESS FOR JOINING GAS DIFFUSION LAYER TO FLOW FIELD PLATE IN A FUEL CELL

Direct all correspondence to: **CORRESPONDENCE ADDRESS**

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ENCLOSED APPLICATION PARTS *(check all that apply)*

☑ Specification *Number of Pages* 11
☐ CD(s), Number
☑ Drawing(s) *Number of Sheets* 5
☑ Other (specify)
☐ Application Data Sheet. See 37 CFR 1.76

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT

☐ Applicant claims small entity status. See 37 CFR 1.27.
☐ A check or money order is enclosed to cover the filing fees
☑ The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number: 04-1928
☐ Payment by credit card. Form PTO-2038 is attached.

FILING FEE AMOUNT ($): $160.00

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒ No.
☐ Yes, the name of the U.S. Government agency and the Government contract number are:

Respectfully submitted,

SIGNATURE Daphne P. Fickes

Date 3/25/03

TYPED or PRINTED NAME DAPHNE P FICKES

REGISTRATION NO. *(if appropriate)* 36,509

Docket Number: DC8507 US PRV

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USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

PROVISIONAL APPLICATION COVER SHEET
Additional Page

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Docket Number	DC8507 US PRV

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Number 2 of 2

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TOTAL AMOUNT OF PAYMENT ($) 160.00

Complete if Known	
Application Number	To Be Assigned
Filing Date	March 24, 2003
First Named Inventor	Peter Andrin et al.
Examiner Name	
Art Unit	
Attorney Docket No.	DC8507 US PRV

METHOD OF PAYMENT *(check all that apply)*

☐ Check ☐ Credit card ☐ Money Order ☐ Other ☐ None

☑ Deposit Account:

Deposit Account Number: 04-1928

Deposit Account Name: E. I. du Pont de Nemours and Company

The Commissioner is authorized to: *(check all that apply)*

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FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
1001	750	2001	375	Utility filing fee	
1002	330	2002	165	Design filing fee	
1003	520	2003	260	Plant filing fee	
1004	750	2004	375	Reissue filing fee	
1005	160	2005	80	Provisional filing fee	160.00

SUBTOTAL (1) ($) 160.00

2. EXTRA CLAIM FEES FOR UTILITY AND REISSUE

			Extra Claims		Fee from below		Fee Paid
Total Claims		-20** =		X	18.00	=	
Independent Claims		- 3** =		X	84.00	=	
Multiple Dependent	☐ YES				280.00	=	

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
1202	18	2202	9	Claims in excess of 20
1201	84	2201	42	Independent claims in excess of 3
1203	280	2203	140	Multiple dependent claim, if not paid
1204	84	2204	42	** Reissue independent claims over original patent
1205	18	2205	9	** Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) ($) 0.00

**or number previously paid, if greater; For Reissues, see above

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
1051	130	2051	65	Surcharge - late filing fee or oath	
1052	50	2052	25	Surcharge - late provisional filing fee or cover sheet	
1053	130	1053	130	Non-English specification	
1812	2,520	1812	2,520	For filing a request for *ex parte* reexamination	
1804	920*	1804	920*	Requesting publication of SIR prior to Examiner action	
1805	1,840*	1805	1,840*	Requesting publication of SIR after Examiner action	
1251	110	2251	55	Extension for reply within first month	
1252	410	2252	205	Extension for reply within second month	
1253	930	2253	465	Extension for reply within third month	
1254	1,450	2254	725	Extension for reply within fourth month	
1255	1,970	2255	985	Extension for reply within fifth month	
1401	320	2401	160	Notice of Appeal	
1402	320	2402	160	Filing a brief in support of an appeal	
1403	280	2403	140	Request for oral hearing	
1451	1,510	1451	1,510	Petition to institute a public use proceeding	
1452	110	2452	55	Petition to revive - unavoidable	
1453	1,300	2453	650	Petition to revive - unintentional	
1501	1,300	2501	650	Utility issue fee (or reissue)	
1502	470	2502	235	Design issue fee	
1503	630	2503	315	Plant issue fee	
1460	130	1460	130	Petitions to the Commissioner	
1807	50	1807	50	Processing fee under 37 CFR 1.17(q)	
1806	180	1806	180	Submission of Information Disclosure Stmt	
8021	40	8021	40	Recording each patent assignment per property (times number of properties)	
1809	750	2809	375	Filing a submission after final rejection (37 CFR 1.129(a))	
1810	750	2810	375	For each additional invention to be examined (37 CFR 1.129(b))	
1801	750	2801	375	Request for Continued Examination (RCE)	
1802	900	1802	900	Request for expedited examination of a design application	

Other fee (specify)

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SUBTOTAL (3) ($) 0.00

SUBMITTED BY				(Complete *(if applicable)*)	
Name *(Print/Type)*	DAPHNE P FICKES	Registration No. *(Attorney/Agent)*	36,509	Telephone	(302) 892-1140
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TITLE

PROCESS FOR JOINING GAS DIFFUSION LAYER TO FLOW FIELD PLATE IN A FUEL CELL

FIELD OF THE INVENTION

The invention relates to a process for joining gas diffusion layers to flow field plates in a fuel cell, and in particular to a process for joining gas diffusion layers to flow field plates in a fuel cell using resistance welding.

BACKGROUND OF THE INVENTION

Polymer electrolyte membrane fuel cells (PEMFC) comprise a membrane electrode assembly (MEA) disposed between two separator plates commonly known as flow field plates. Within the MEA lies a catalyst-coated membrane that lies between a pair of fluid distribution layers, commonly referred to as gas diffusion layers (GDL). The catalyst-coated membrane comprises an ion exchange membrane coated by two catalyst layers. The catalyst-coated membrane is placed between the two GDL and is compressed to form the MEA.

The GDL are made of porous, electrically conductive material, such as carbon cloth or carbon paper. The GDL provide uniform fuel and oxidant distribution to the catalyst-coated membrane and facilitates the transport of water from the catalyst layers. The GDL also provides electrical contact between the catalyst layers and flow field plates.

The morphology, composition, porosity, tortuosity and thickness of the GDL impact the overall performance of the fuel cell under different operational conditions. The nature and extent of contact between the GDL and the flow field plates significantly contributes to the conductivity of the fuel cell. Close contact between the GDL and flow field plates results in optimum conductivity by decreasing the resistive loss between the GDL and flow field plates.

A fuel cell typically functions as a series of connected fuel cells, called a fuel cell stack. In the fuel cell stack, the stack compression force controls the nature and extent of contact between the GDL and flow field plates. While a high stack compression force may provide good contact between the GDL and flow field plates, it often causes local damage to the structure of the GDL. A high stack compression force can also changes the morphology of the porous GDL and impede the flow of oxidant and fuel to the catalyst layers. This impediment can lead to starvation at the reactive sites on the catalyst layers and a resultant decrease in the performance of the fuel cell.

In addition, the uneven flatness of the flow field plates as well as the uneven landing surfaces of the flow field channels may cause uneven contact across the GDL. This uneven contact results in disruption of the conductivity between the GDL and flow field plates. It can also result in localized deformation of the GDL.

Attempts have been made to increase the contact area between the GDL and landing surfaces of the flow field plates. One proposed method is to roughen the landing surfaces of the flow field plates to increase the overall area of contact and facilitate penetration of the roughened areas into the pores of the GDL. However, the effect of this process is largely dependent on the compression force applied to the stack and therefore provides very little advantage over a non-roughened landing surface.

There, therefore, remains a need to provide a process for improving the nature and extent of contact between the GDL and flow field plates while not increasing the stack compression force of the fuel cell stack.

SUMMARY OF THE INVENTION

The present invention provides a process for joining the GDL to flow field plates in the fuel cell.

According to one aspect of the invention there is provided a process for joining a gas diffusion layer to a flow field plate of a fuel cell said flow field plate comprising a polymer/graphite composition and having at least one landing surface, wherein said process comprises the step of welding the landing surface to the gas diffusion layer.

In a second aspect, the present invention provides a fuel cell component comprising a gas diffusion layer welded to a flow field plate, wherein the flow field plate comprises a polymer/graphite composition and at least one landing surface, and wherein a portion of the polymer on the landing surface is impregnated within the gas diffusion layer.

In one embodiment of the invention resistance, welding is used to join the GDL to the flow field pate.

In another aspect of the invention, a fuel cell is prepared by the process of the present invention, in which the GDL of the fuel cell are joined to the flow field plates.

The preferred embodiments of the present invention can provide many advantages. For example, the process of the present invention improves the contact between the GDL and landing surfaces of the flow field plates and provides uniform conductivity across the MEA and flow

field plates. It results in negligible resistive loss between the GDL and flow field plates leading to better performance of the fuel cell stack.

Numerous other objectives, advantages and features of the process will also become apparent to the person skilled in the art upon reading the detailed description of the preferred embodiments, the examples and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The preferred embodiments of the present invention will be described with reference to the accompanying drawings in which like numerals refer to the same parts in the several views and in which:

Figure 1a is an exploded perspective view of a typical polymer electrolyte membrane fuel cell;

Figure 1b is an exploded perspective view of a typical polymer electrolyte membrane fuel cell as part of a fuel cell stack;

Figure 2a is a partial side perspective view of a flow field plate and gas diffusion layer;

Figure 2b is a close up view of flow field channels and landing surfaces on a flow field plate; and

Figure 3 is a schematic drawing of a weld created between a flow field plate and a gas diffusion layer in accordance with a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiments of the present invention will now be described with reference to the accompanying figures.

The present invention provides a process for improving the electrical contact between the GDL and the flow field plates of a fuel cell within a fuel cell stack without increasing the stack compression force.

As shown in Figure 1, a typical polymer electrolyte membrane fuel cell comprises a MEA disposed between two flow field plates 5. The MEA includes a catalyst-coated membrane 10 disposed between two gas diffusion layers (GDL) 15. The GDL 15 are adjacent to flow field plates 5, which form the outer layers of the fuel cell.

The flow field plates 5 comprise at least one flow field channel 20, which allows gas or liquid to flow to and from the fuel cell. The flow field plates 5 typically carry either fuel or oxidant depending on the design of the fuel cell or fuel cell stack.

In a preferred embodiment, the present invention provides a process for joining the GDL 15 to the flow field plates 5 of a fuel cell by

partially impregnating the composite plate material of the flow field plate 5 into the pores of the GDL 15.

Impregnation of the composite material of the flow field plate 5 is facilitated by the configuration and composition of the flow field plates 5. As shown in Figures 2a and 2b, the flow field channels 20 are configured with landing surfaces 25, which are raised surfaces that form the top barrier walls of the flow field channels 20. The dimension of the landing surfaces 25 may vary according to the fuel cell design. In a preferred embodiment, the width and height of the landing surfaces 25 are from 0.5 mm to 2.5 mm, preferably from 0.8 mm to 1.5 mm.

The flow field plates 5 are generally molded from a composition comprising graphite fiber, polymer and graphite powder. The polymer can be any thermoplastic polymer or any other polymer having characteristics similar to a thermoplastic polymer. Preferably the polymer is an aromatic polyester resin such as that available from E.I. du Pont de Nemours and Company under the trademark ZENITE®. The graphite fiber is preferably a pitch-based graphite fiber having a fiber length distribution range from 15 to 500 μm, a fiber diameter of 8 to 15 μm, bulk density of 0.3 to 0.5 g/cm^3 and a real density of 2.0 to 2.2 g/cm^3. The graphite powder is preferably a synthetic graphite powder with a particle size distribution range of 20 to 1500 μm, a surface area of 2 to 3 m^2/g, bulk density of 0.5 to 0.7 g/cm^3 and real density of 2.0 to 2.2 g/cm^3. Further detail regarding the composition of the flow field plates 5 is described in U.S. Patent No. 6,379,795 B1, which is herein incorporated by reference.

To join the GDL 15 to the flow field plates 5, the GDL 15 is welded to the landing surfaces 25 using resistance welding. The general process for resistance welding is set out in U.S. Patent No. 4,673,450 to Burke, which is hereby incorporated by reference. However, its application to fuel cells has not yet been explored.

With the resistance welding process, an alternating or direct electrical current is used to create welds between the landing surfaces 25 and the GDL 15. The electrical current is passed between the GDL 15 and flow field plates 5 bringing the landing surfaces 25 and GDL 15 closer together so that they are in close proximity. Pressure may also be applied to the GDL 15 and flow field plates 5 at the outset of the welding process to keep the GDL 15 and flow field plates 5 together. During the resistive welding process, a constant pressure is also applied to the GDL 15 to hold the GDL 15 against the landing surfaces 25.

As the electrical current flows through the flow field plates 5 and GDL 15, the contact areas between the GDL 15 and landing surfaces 25 experiences a relatively higher resistance than the independent GDL 15 and landing surfaces 25, resulting in the production of localized heat at the contact areas. This localized heat melts the polymer component of the landing surfaces 25 and allows the graphite fiber and graphite powder components of the landing surface 25 to establish direct contact with the carbon matrix of the GDL 15, thereby creating a contact region. At this point, the flow of electrical current is stopped, thus also stopping the production of localized heat. As pressure continues to be applied against the GDL 15 and landing surfaces 25, the molten polymer component of the landing surfaces 25 impregnates into the pores of the GDL 15. With continued pressure the molten polymer component of the landing surfaces 25 solidifies into the pores of the GDL 15 and around the contact region, thereby fusing the GDL 15 to the flow field plates 5 at the landing surfaces 25. Localized heat production stops when the electrical current is withdrawn and the temperature of the flow field plates 5 drops quickly to a temperature well below the glass transition temperature of the polymer (about 220 °C). As a result, the fused area between the landing surfaces 25 and GDL 15 forms a permanent weld 40 (see Figure 3).

The electrical current can be applied directly to the flow field plates 5 and GDL 15 using electrodes. The amperage, voltage, design pressure and span of electrical current flow will vary depending on the surface area of the landing surfaces 25, the size of the pores of the GDL 15 and the degree of melting at the landing surface 25. However, in a preferred embodiment, the applied electrical current is between about 0.1 amperes/mm^2 and about 3 amperes/mm^2, preferably between about 0.8 and about 1.1 amperes/mm^2 and its voltage is between about 1 and about 10 volts, preferably between about 3 and about 5 volts. The resistance welding process spans between about 1 and about 10 seconds, preferably between about 3 and about 4 seconds and the applied pressure is between about 1 and about 10 psig, preferably between about 3 and about 4 psig.

It will be apparent to those skilled in the art that other welding techniques such as vibration welding, ultrasonic welding, laser welding, heat lamination, or hot bonding techniques may also be used within the scope of the invention.

The process for joining the GDL 15 to the flow field plates 5 can be used to create a fuel cell that include GDL 15 permanently fused to the flow field plates 5 within the fuel cell. This fuel cell design will have significant advantages such as improved efficiency and decreased production time.

The following examples illustrate the various advantages of the preferred method of the present invention.

EXAMPLES:

Example 1

A composite plate comprising 25% Zenite® 800, 55% Thermocarb® graphite powder and 20% graphite fiber was welded to a gas diffusion layer comprising porous E-Tek® carbon cloth. The landing surface of the plate had a length of 60 mm, a width of 20 mm and a thickness of 4 mm.

A jig was fabricated specifically to apply a direct current mediated by two electrodes directly to the composite plate and gas diffusion layer. A welding machine was used as a power source. The jig also applied and controlled the pressure on the composite plate and gas diffusion layer. A gas cylinder was used as the pressure source. The composite plate and the gas diffusion layer were placed in the jig (for Butt welding position) and a 90-ampere (90 A) current was passed through the composite plate and gas diffusion layer for 3.5 seconds. A pressure of 3.5 psig was applied to hold the gas diffusion layer against the landing surfaces of the plate.

Gas diffusion layers comprising different surface morphology and pore structure required different welding conditions. GDL-1 comprises a weaved carbon cloth material and has a regular metric structure. GDL-2 comprises a non-weaved carbon cloth material. It has an irregular surface porosity. GDL-3 comprises a small porous structure and has increased rigidity when compared with GDL-1 and GDL-2. In each case, welding of the gas diffusion layer to the landing surface was achieved. Table 1 compares the variation in welding conditions for three different gas diffusion layers.

Table 1: Welding Parameters

Welding Parameters	GDL – 1	GDL – 2	GDL – 3
Current (amp)	70	90	90
Pressure (psig)	3.0	3.5	2.5
Weld Time (s)	3	3.5	3.5

Although the present invention has been shown and described with respect to its preferred embodiments and in the examples, it will be understood by those skilled in the art that other changes, modifications, additions and omissions may be made without departing from the substance and the scope of the present invention as defined by the attached claims.

CLAIMS

What is claimed is:

1. A process for joining a gas diffusion layer to a flow field plate of a fuel cell said flow field plate comprising a polymer/graphite composition and having at least one landing surface, wherein said process comprises the step of welding the landing surface to the gas diffusion layer.

2. The process of Claim 1 wherein the landing surface is welded to the gas diffusion layer using resistance welding.

3. The process of Claim 2 wherein resistance welding comprises the steps of:

(a) placing the landing surface in contact with the gas diffusion layer;

(b) applying an electrical current between the gas diffusion layer and the flow field plate to produce localized heat at the landing surface sufficient to melt the polymer in the landing surface and produce molten polymer; and

(c) ceasing to apply the current and applying pressure to the landing surface and gas diffusion layer to create a weld between the gas diffusion layer and the landing surface by allowing the molten polymer to cool and solidify.

4. The process of Claim 3 wherein the electrical current is between about 0.1 amperes/mm2 and about 3 amperes/mm2, preferably between about 0.8 and about 1.1 amperes/mm2 and its voltage is between about 1 and about 10 volts, preferably between about 3 and about 5 volts and the electrical current is applied over about 1 to about 10 seconds, preferably over about 3 to about 4 seconds.

5. The process of Claims 3 or 4 wherein the applied pressure is between about 1 and about 10 psig, preferably between about 3 and about 4 psig.

6. The process of Claim 1 wherein the landing surface is welded to the gas diffusion layer using a technique selected form resistance welding, vibration welding, ultrasonic welding, laser welding, heat lamination, and hot bonding.

7. The process of any one of Claims 1 to 6, wherein the polymer/graphite composition of the flow field plate comprises graphite filler, polymer and graphite powder.

8. A fuel cell comprising a gas diffusion layer and a flow field plate, wherein the gas diffusion layer is welded to the flow field plate using the process of any one of claims 1 to 7.

9. A fuel cell component comprising a gas diffusion layer welded to a flow field plate, wherein the flow field plate comprises a polymer/graphite composition and at least one landing surface, and wherein a portion of the polymer on the landing surface is impregnated within the gas diffusion layer.

10. The fuel cell component of Claim 9, wherein the portion of polymer on the landing surface is impregnated within the gas diffusion layer by welding the landing surface to the gas diffusion layer.

11. The fuel cell component of Claim 10, wherein welding is achieved by resistance welding.

12. The fuel cell component of Claim 11, wherein resistance welding comprises the steps of:

(a) placing the landing surface in contact with the gas diffusion layer;

(b) applying an electrical current between the gas diffusion layer and the flow field plate to produce localized heat at the landing surface sufficient to melt the polymer in the landing surface and produce molten polymer; and

(c) ceasing to apply the current and applying pressure to the landing surface and gas diffusion layer to create a weld between the gas diffusion layer and the landing surface by allowing the molten polymer to cool and solidify.

13. The fuel cell component of Claim 12 wherein the electrical current is between about 0.1 amperes/mm2 and about 3 amperes/mm2, preferably between about 0.8 and about 1.1 amperes/mm2 and its voltage is between about 1 and about 10 volts, preferably between about 3 and about 5 volts and the electrical current is applied over about 1 to about 10 seconds, preferably over about 3 to about 4 seconds.

14. The fuel cell component of Claim 13 wherein the applied pressure is between about 1 and about 10 psig, preferably between about 3 and about 4 psig.

15. The fuel cell component of Claim 10 wherein the landing surface is welded to the gas diffusion layer using a technique selected form resistance welding, vibration welding, ultrasonic welding, laser welding, heat lamination, and hot bonding.

16. The fuel cell component of any of Claims 9 to 15, wherein the polymer/graphite composition of the flow field plate comprises graphite filler, polymer and graphite powder.

17. A fuel cell stack comprising a plurality of the fuel cells of Claim 8.

18. A fuel cell stack comprising a plurality of the fuel cell components of any of Claims 9 to 16.

TITLE

PROCESS FOR JOINING GAS DIFFUSION LAYER TO FLOW FIELD PLATE IN A FUEL CELL

ABSTRACT

There is provided a process for joining the gas diffusion layer to a flow field plate in a fuel cell. The process comprises the step of welding the landing surface of the flow field plate to the gas diffusion layer using resistance welding.

DPF/dmm

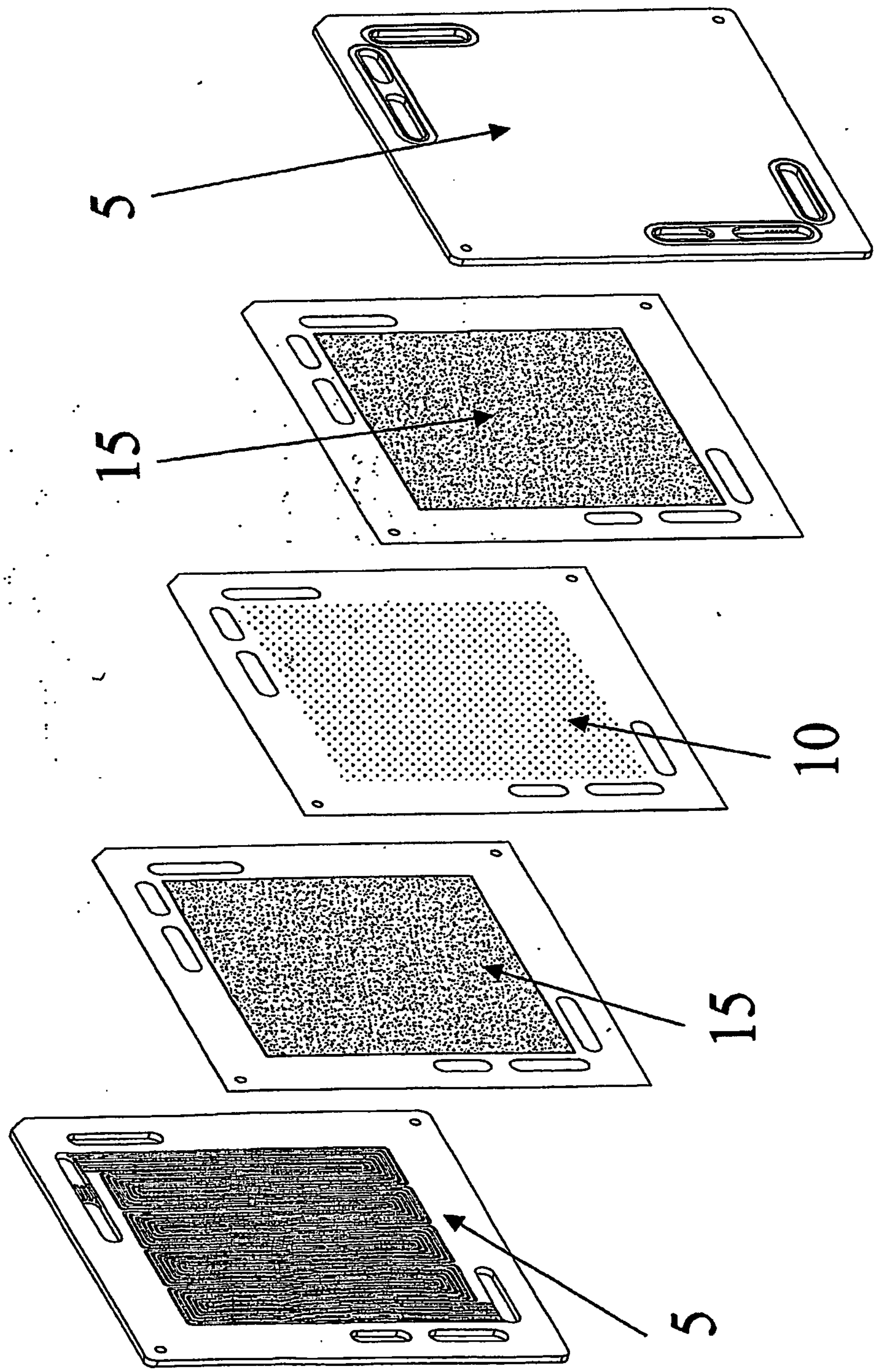

Figure - 1a

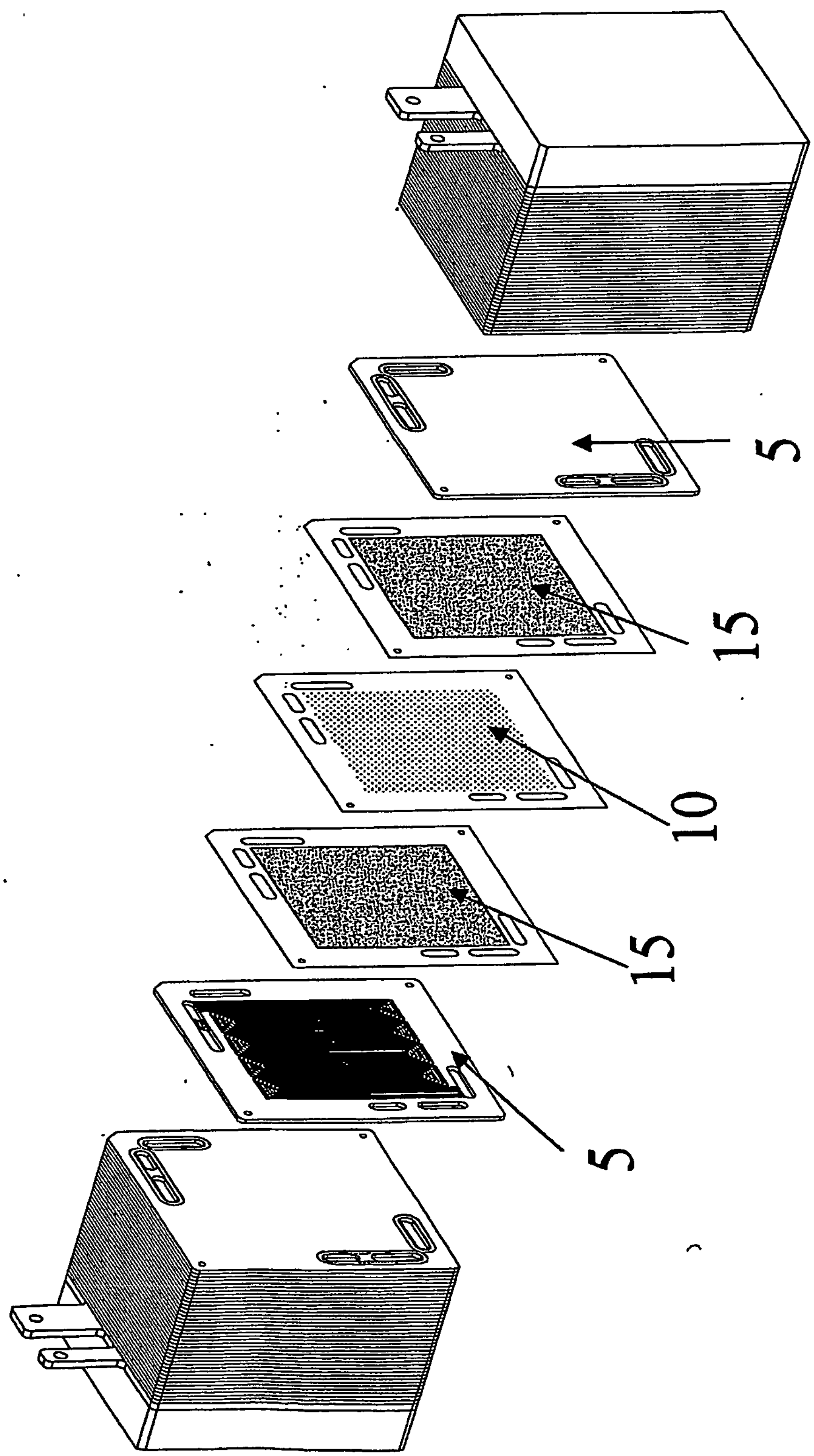

Figure - 1b

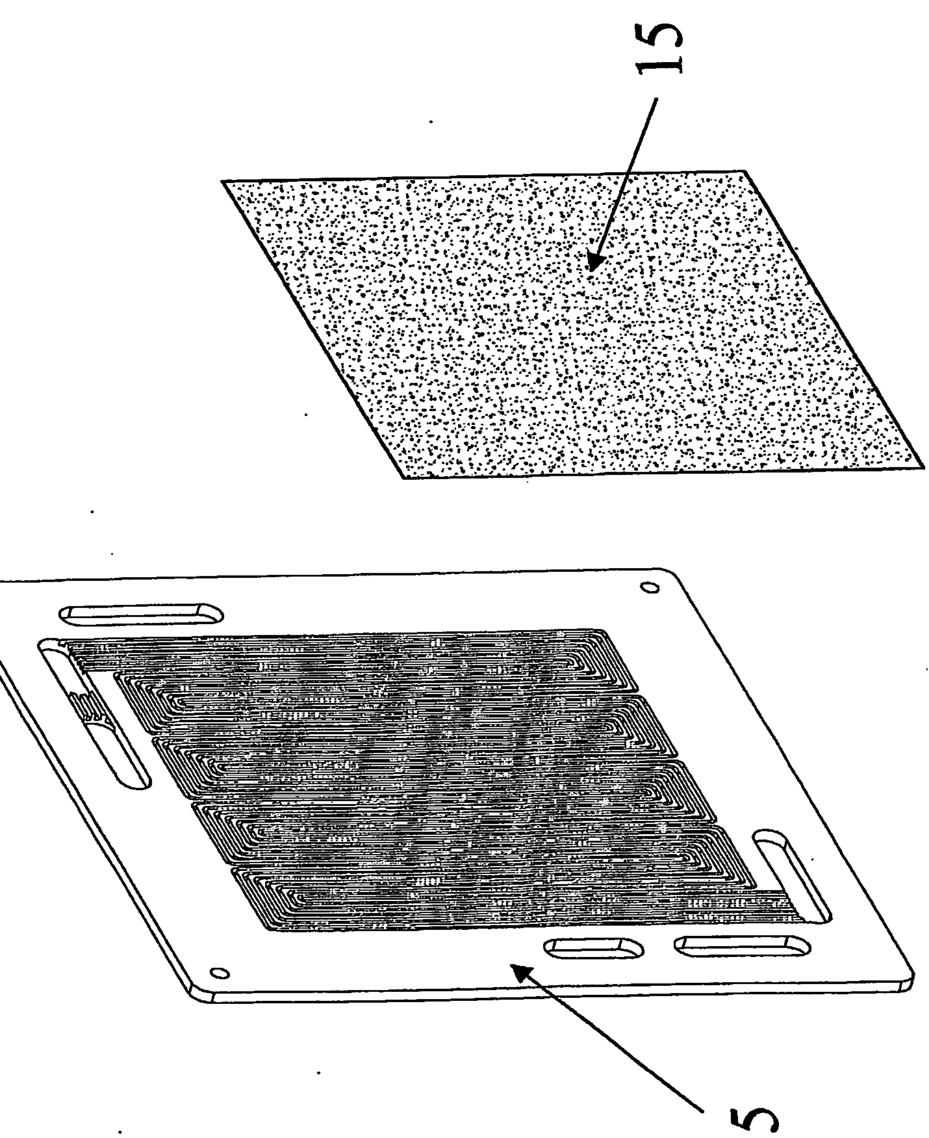

Figure – 2a

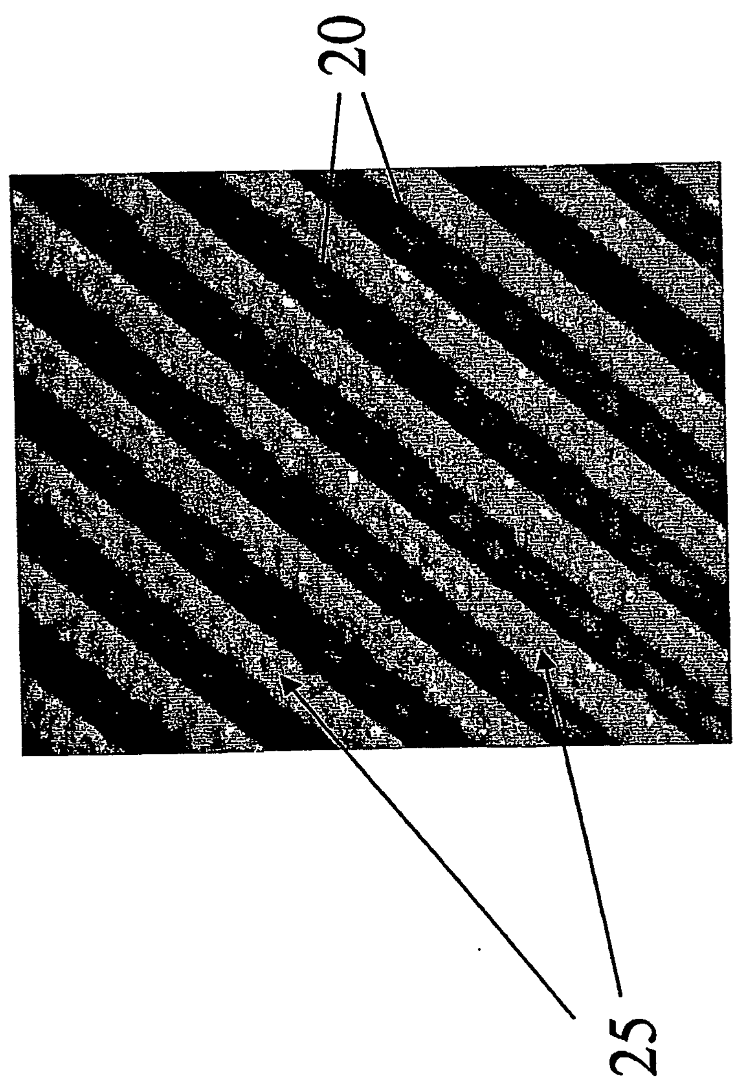

Figure – 2b

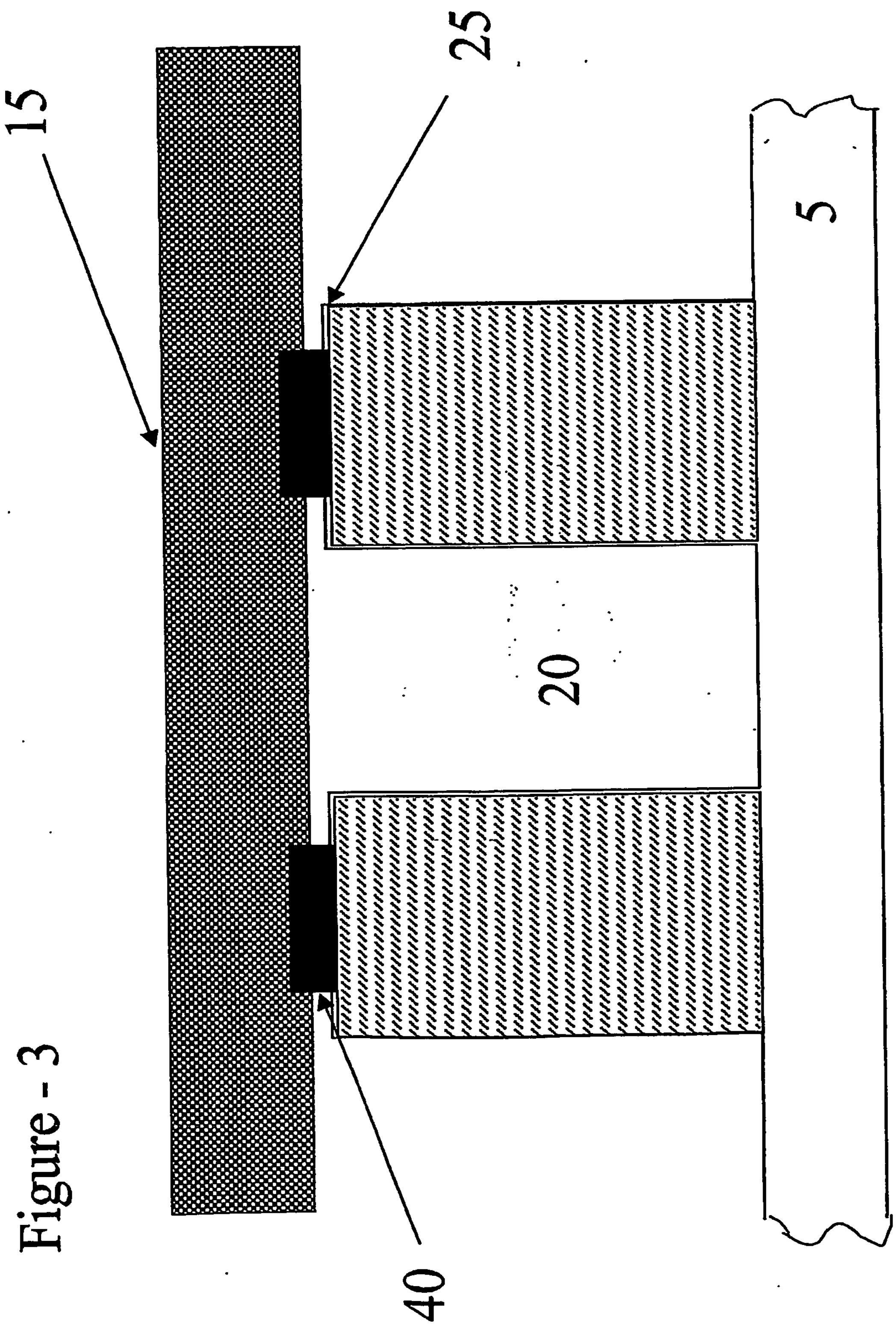

Figure - 3